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Impact of renewables deployment on the CO_2 price and CO_2 emissions in the European electricity sector

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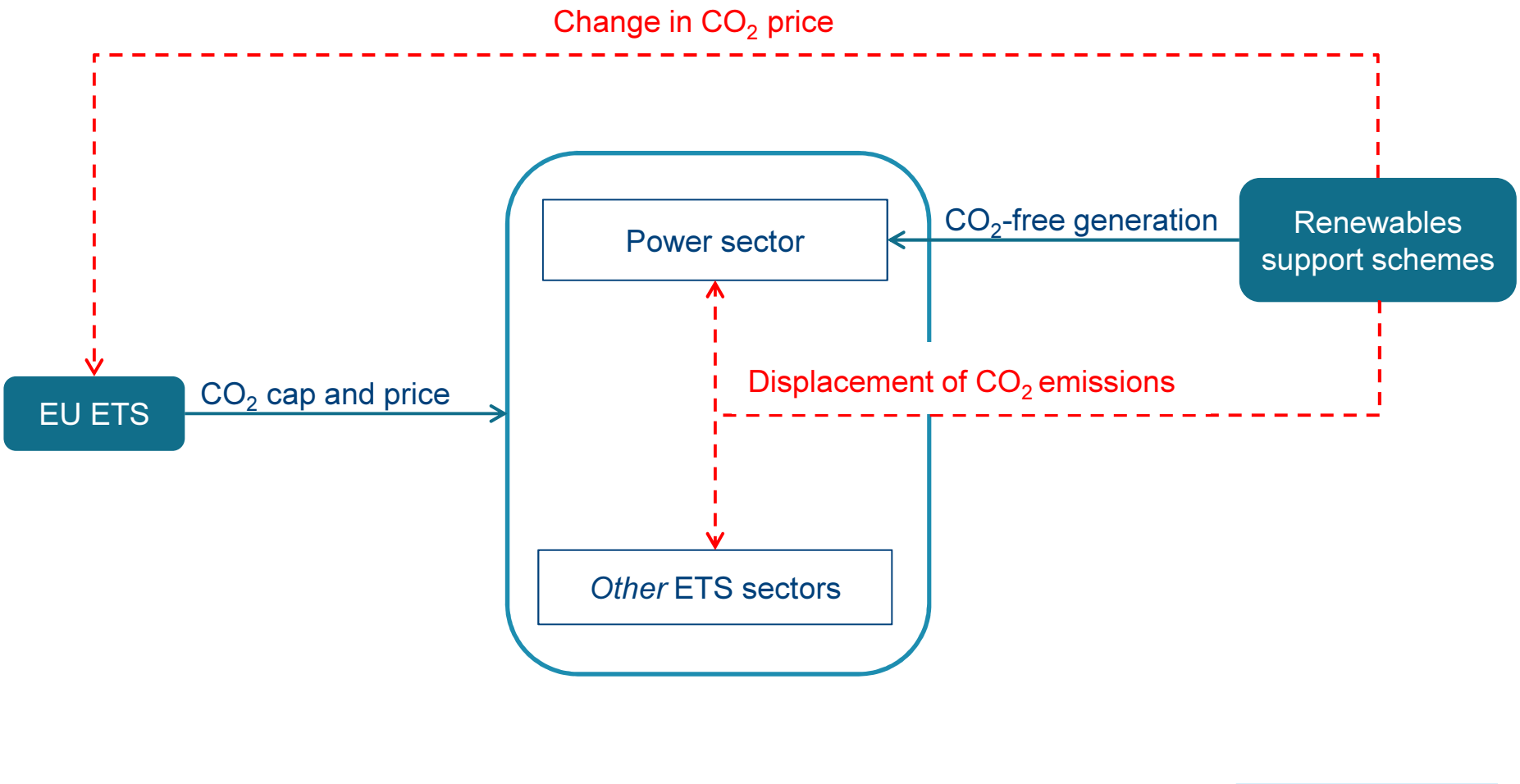
Introduction
Framework

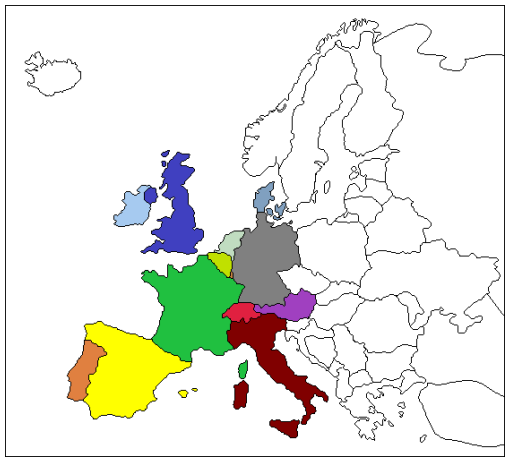


Research question

Given a certain amount of renewable injections, what is the effect on ...

- the EU ETS CO_2 price?
- CO_2 emission displacement within the EU ETS?

- ✓ Focus on power sector
- ✓ Pure operational study
- ✓ Quantitative approach
- ✓ Ex-post analysis for 2007-2010
- ✓ Western and Southern Europe



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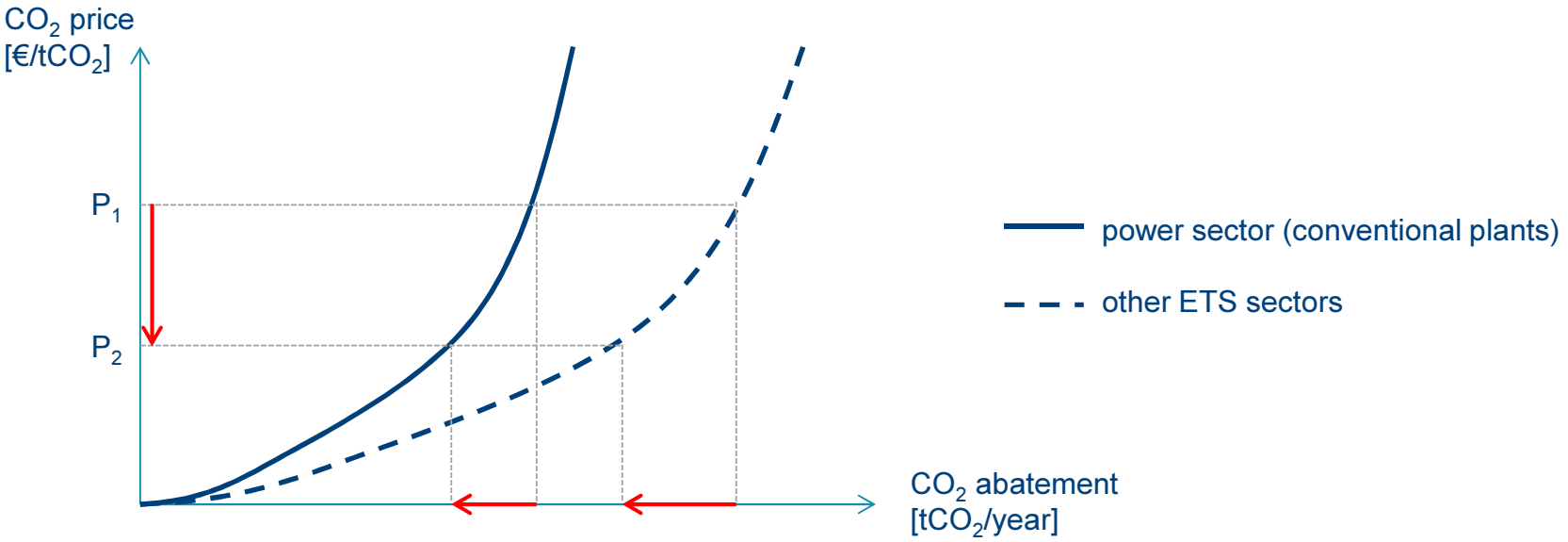
Methodology

The challenge we face

Can we say something about the EU ETS price-emission relationship when focusing solely on the power sector?



Methodological example of effect of renewables deployment in the power sector

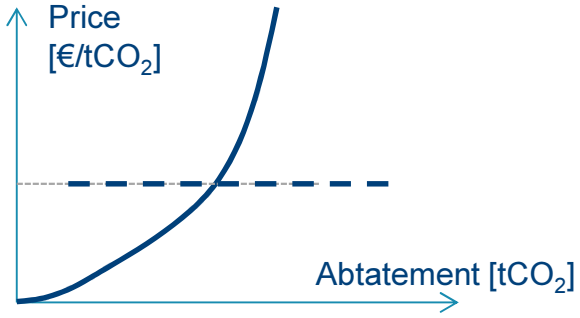
Methodology

The solution we propose

We don't know the MACC of the other ETS sectors, but 2 extremes are possible

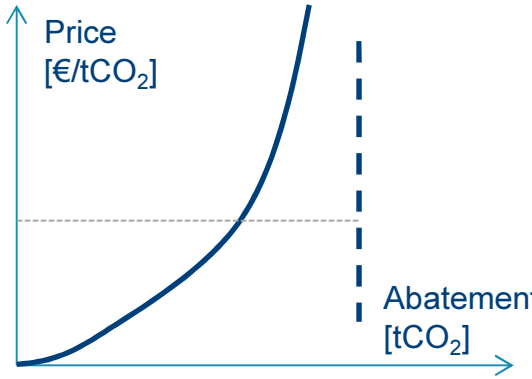
ETS-price assumption

- All equivalent abatement possible in other ETS sectors at current CO_2 price
- Power sector experiences EU ETS as CO_2 tax
- Renewables cause only CO_2 displacement away from power sector (outer limit)



ETS-cap assumption

- No change abatement possible in other ETS sectors at "any" CO_2 price
- Power sector experiences EU ETS as sectorial cap
- Renewables cause only CO_2 price decline (outer limit)



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Methodology

The analysis plan

Approach

1. Simulate the impact of renewables deployment according to the 2 extremes
2. Determine all possible situations between these 2 extremes
3. The ‘real’ solution lies somewhere on this curve

Limitations of the analysis

- Conventional generation system is assumed to be fixed
- No low-carbon investments triggered by a high CO_2 price
- All wind, sun and bio assumed to be the result of support schemes

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Methodology

The simulation model

- Operational market model
  - System cost minimization
  - Formulated as a linear program (LP)
  - Hourly time step
  - Technology per country basis
  - Deterministic with inelastic demand
- Subject to
  - Supply-demand balance
  - Power plant technical constraints: operating range and ramping
  - Network constraints (NTC market coupling)
  - Pumped storage available
- Calibration based on the historical observed situation, solved for different years
- Input data from Eurelectric, ENTSO-e, TSO's and commodity exchanges

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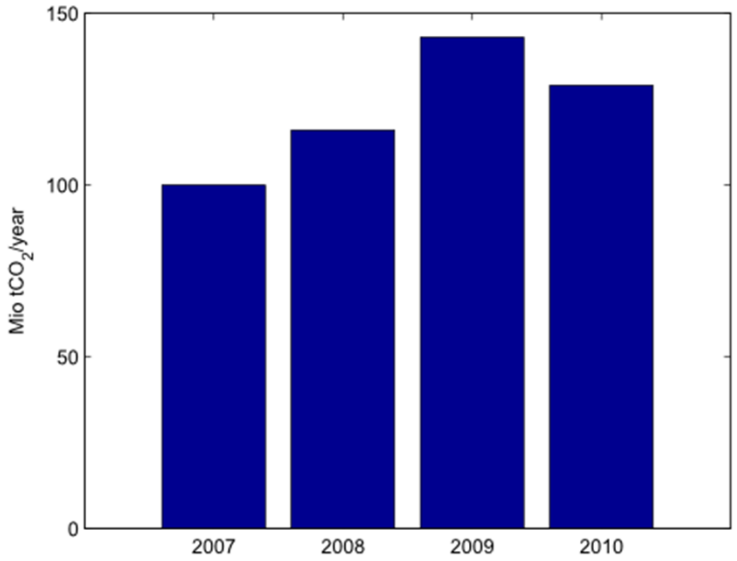
Results

CO_2 displacement according to ETS-price assumption

The historical amount of wind, sun and bio generation caused ...

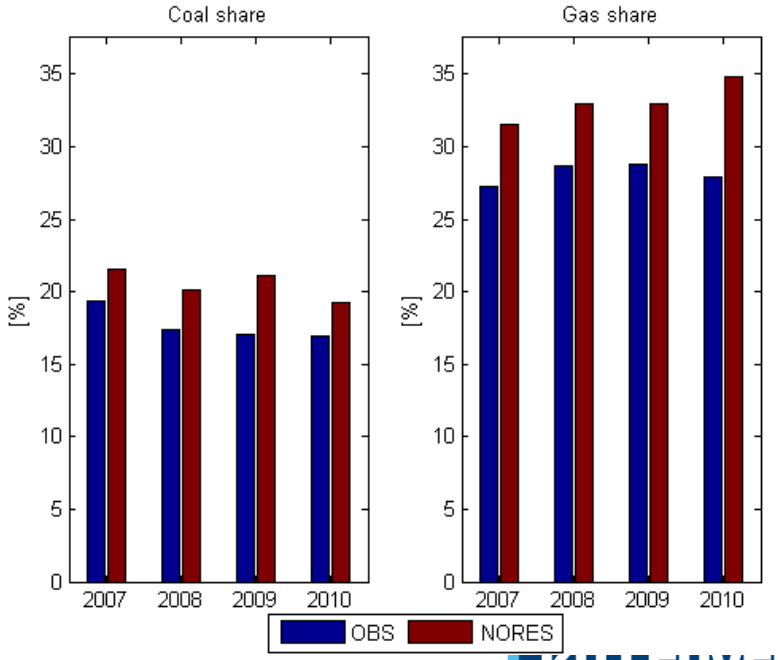
CO_2 displacement

- From the power sector to other ETS sectors
- Respectively 10%, 13%, 16% and 15% of historical emissions



Fuel share changes

- A decrease in both coal and gas shares



Results

CO_2 displacement according to ETS-cap assumption

The historical amount of wind, sun and bio generation caused ...

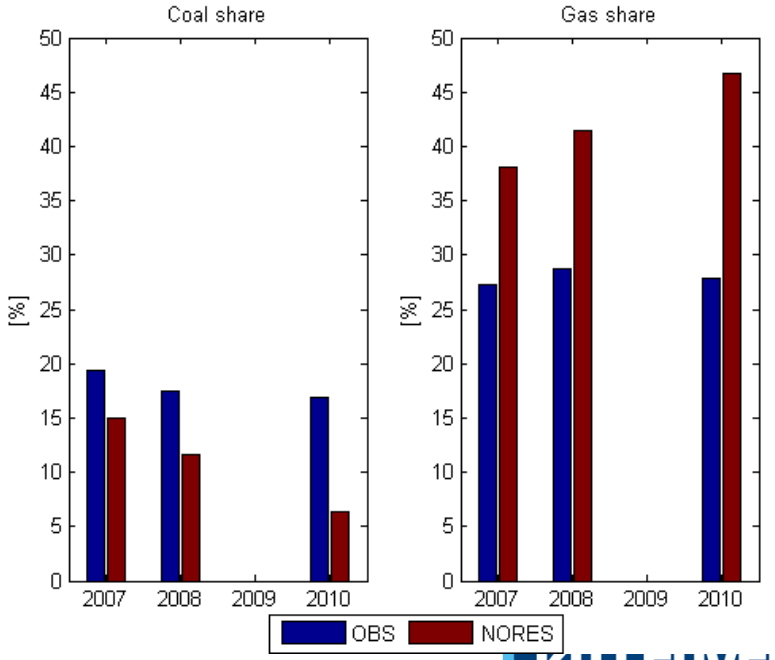
CO_2 price decrease

- CO_2 price needed to keep emissions constant without renewables
- In 2009, impossible to reach historical emissions

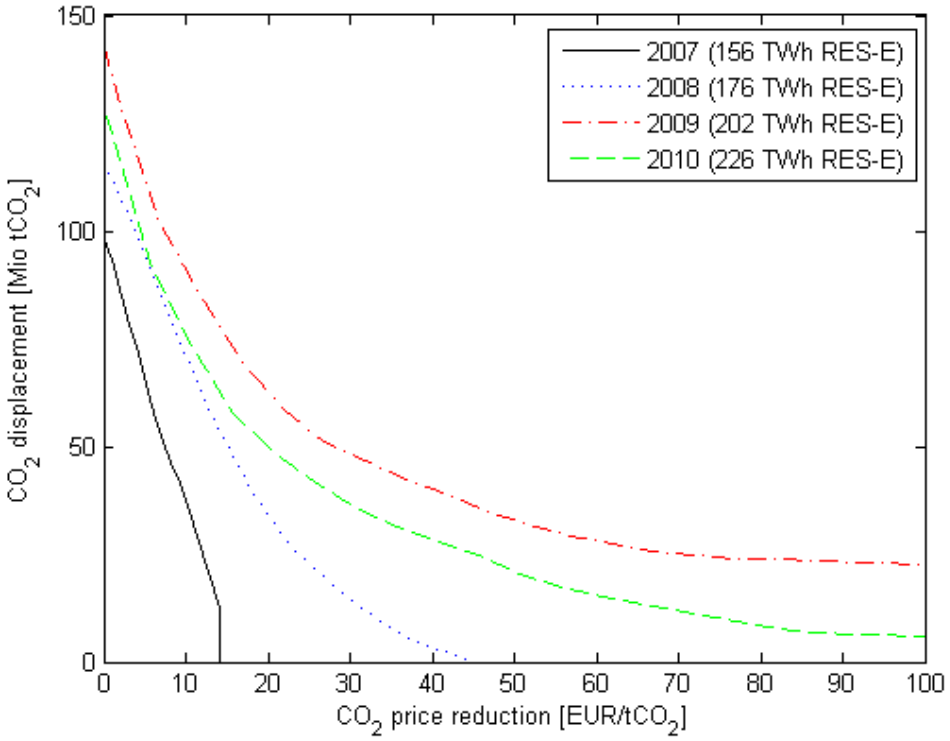
CO_2 price [EUR/tCO2]	OBS	NORES
2007	1	15
2008	22	68
2009	13	∞
2010	14	474

Fuel share changes

- Higher coal share at the expense of a lower gas share



Combining both assumptions into the impact curve



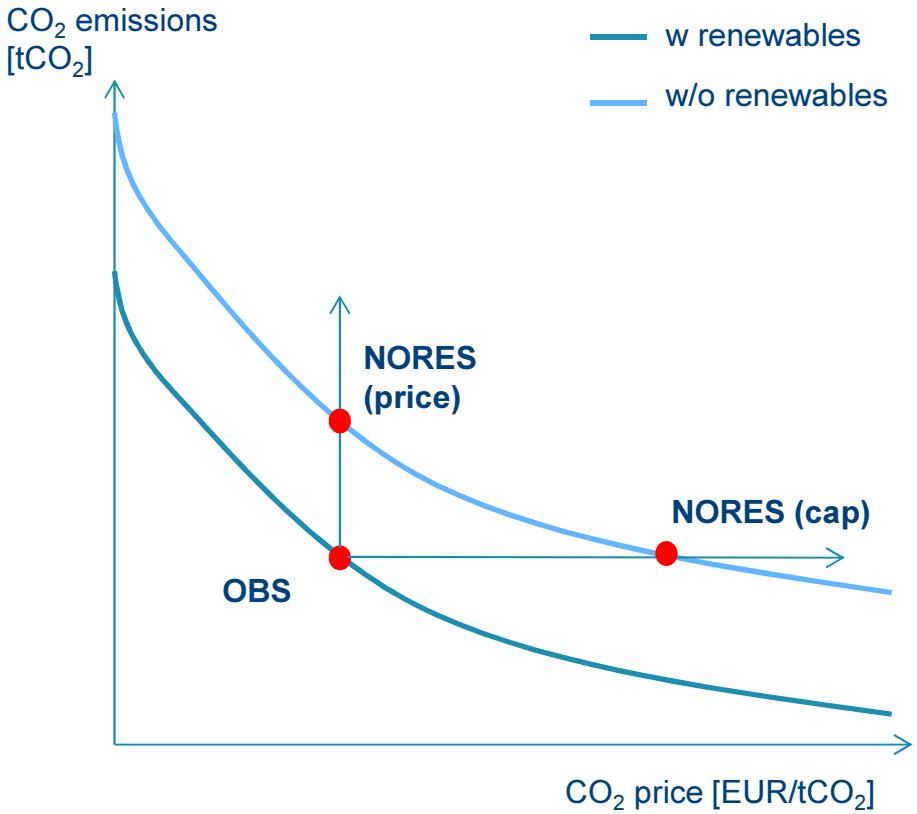
Range of possible effects of historical renewable generation in terms of CO_2 price reduction and CO_2 displacement from the power sector towards other ETS sectors.

How to construct/understand this figure?

- Intersection with y-axis refers to ETS-price assumption
- Intersection with x-axis refers to ETS-cap assumption.
- Take scenario w/o RES and CO_2 price between historical and maximal value
- Compare CO_2 emissions from power sector and CO_2 price to OBS and plot differences
- Figure only valid relative to historical reference point.

What's behind the impact curve?

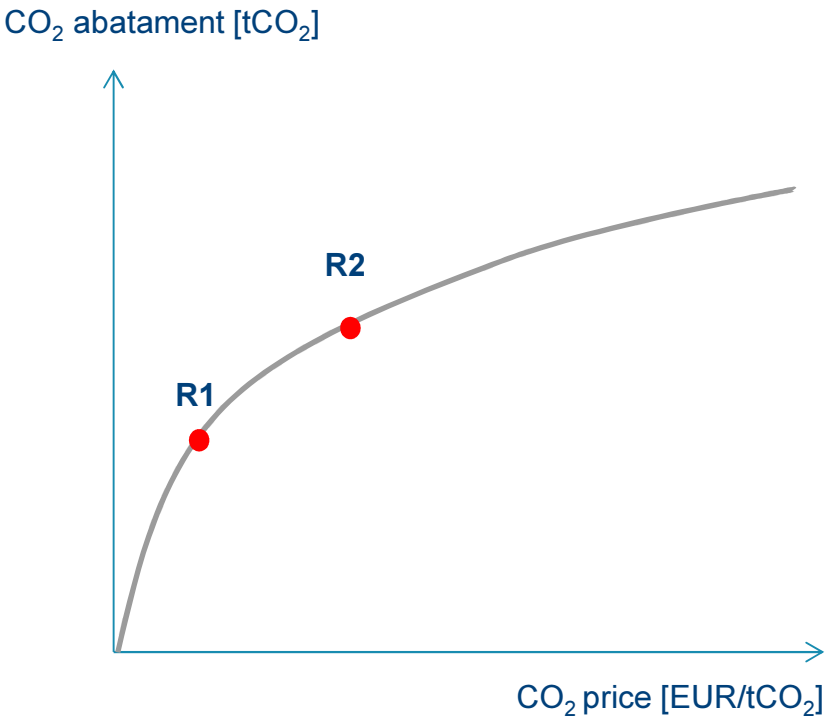
Link with the absolute emission curve



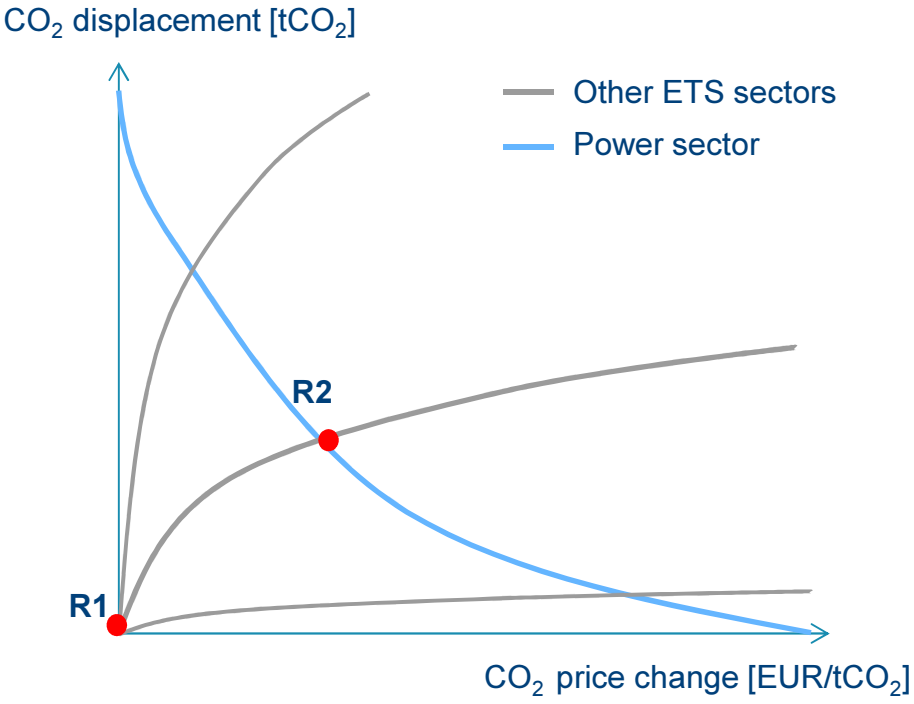
Absolute CO_2 emission curve from the power sector

What is the actual impact of renewables?

The intersection of the impact curve with the MACC of the other ETS sectors



MACC of other ETS sectors



Intersection MACC other ETS sectors and impact curve

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Conclusions

What is the historical impact of renewables on EU ETS (CO_2 price and CO_2 emissions)?

- Solely based on the power sector, one can quantify a range of possible effects of renewables on EU ETS
- The CO_2 price decrease caused by renewables deployment turns out to be likely significant
- CO_2 emission displacement from the power sector to other ETS sectors due to renewables deployment can be up to more than 10 % of historical emissions in the power sector
- Knowledge about the non-power sectors under the EU ETS is needed to determine actual impact of renewables deployment

Currently, the methodology is further elaborated on in a new paper

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